PREVENTION OF FROST INJURY TO FRUIT CROPS.

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EFFECT OF FROST ON FRUIT CROPS.

The fruit grower, from time immemorial, has been at the mercy of the elements. Frost is one of the most formidable foes with which he has to contend. Millions of dollars are lost annually by silent, relentless frosts that come either when the trees are in blossom or just after the fruit has set.

Recent demonstrations in the fruit district of the Middle West have proved beyond a peradventure that damage to fruit trees by frost can be controlled to a greater or less extent. One of the fundamental principles that underlie successful frost fighting is a knowledge of the subject of air drainage. Cold air, like water, settles to the lowest ground, and anything that will break up this stratum of cold air and cause it to mix with the upper strata of warm air will prove of great value in combating frost injury.

Frost injury to fruit trees most frequently occurs when there is a clear, still, dry atmosphere, and when the radiation is uninterrupted by clouds or moisture, and the cold air settles in poorly air-drained areas.

While frosts may not be severe, they are often just severe enough to damage the blossoms and tender fruits, and they not only reduce a crop of fruit one-third to one-half of what it should be, but sometimes destroy the entire crop for one year or for several successive years.

In order to overcome destructive atmospheric conditions three original methods have been tried: (1) Explosives, (2) smudges, (3) heating devices.

EXPLOSIVES.

Explosives were first used in the vineyard districts of Austria, France, and Italy, where hailstorms and frost were prevalent and were destructive to the grape crop.

Many years ago, Mr. Albert Stiger, burgomaster, Windisch-Briestrits (Lower Steirmark, Austria), we are informed, owned extensive vineyards on the lower slopes of the Bacher Mountains, a locality persistently visited by destructive hailstorms. He decided to drive

the clouds away by the use of explosives and he established six stations on six of the surrounding mountains, a locality 2 miles in extent. The stations, built of wood, sheltered ten heavy mortars each, and near each station was a cabin in which powder was stored. A corps of volunteers consisting of neighbors and owners of small vineyards was trained to proceed to the stations and handle the mortars whenever there was the slightest indication of a storm. Each mortar was loaded with about 4½ ounces of powder; the firing was simultaneous and continuous until the clouds were either scattered or blown away. This also had a tendency to break up the stratum of cold air and prevent its settling in the low grounds. These experiments were practiced for some time and are said to have been successful.

SMUDGES.

The damage to fruit buds by frost is more severe when the sun's rays, following a night of cold, are allowed to fall on the trees. To prevent this sudden change from freezing to thawing the system of smudging was adopted.

After many series of experiments it is said that Mr. Bellot des Minieres recommended the accumulation at various points in the orchard or vineyard of combustible matter capable of producing a thick, black smoke. He believed that if heaps of fuel were set on fire at sunrise, the resultant smoke would make a thick, black, impenetrable veil that would protect the vines from the sun's rays and would maintain a general temperature in the vineyard at a point that would counteract the effects of frost. The purpose of this method is to prevent the radiation of heat from the earth's surface and to shield the fruit buds from the sun's rays by creating a cloud of smoke over the area to be protected.

Consul D. I. Murphy, Bordeaux, France, 1908, reports a device invented by Mr. Edouard Lestout, of that city, for making artificial clouds for the protection of vineyards. Small wooden boxes, open at the top, were filled with an inflammable compound consisting of equal parts of resinous and earthy substances, such as clay and the like, reduced to fine powder and pressed into a compact mass. In the center of each box a wick extended through the mass and served to ignite it; or the wick could be dispensed with and the compound ignited by pouring over it a few drops of kerosene or alcohol and lighting it with a match. The boxes were made of pine wood and were 8 inches long by 6 inches wide, and were placed 30 feet apart in the vineyard. The most dangerous frost period for grapes was found to be in April, when the young shoots were showing vigor and the sap was flowing freely. Mr. Lestout found little danger from a dark or cloudy morning that followed a cold night, but the danger

occurred on the clear mornings when the sun's rays shone directly on the unprotected plants. This invention probably led to the use of the smudging devices so extensively used subsequently in California.

Vapor smudge, as first used, is accredited to Meacham. Small areas were covered with wet straw, manure, and cypress brush; this material was burned in quantities and evaporating pans were constructed which were calculated to have a sufficient capacity for furnishing enough vapor to cover the areas owned by the individual operator. It is said that eminent engineers made estimates for such work, but they miscalculated the absorptive power of large, adjacent dry-air bodies, and the vapor, as fast as generated, disappeared into space. They evidently failed to note the fact that they began their work in the valleys at the lowest stratum of cold air, and that to be effective the vapor-producing heat should have been radiated from the areas above the valley.

This method had also the weak point of necessitating the cooperation of every landowner in the valley. It had to be accomplished on a wholesale scale to be effective, for no individual could cope single handed with the elements.

In early days, pioneer lemon growers in California located their groves in the valleys, with no thought of the law governing the gravitation of cold air, and their efforts resulted in almost complete failure. The cold air from the snow-capped mountains flowed down to the lowest ground whenever there was no wind to keep up the circulation. This mistake was soon discovered and subsequently plantings were made upon higher plateaus.

HEATING DEVICES.

THE USE OF COAL FOR HEAT.

Edward Copley is credited with inventing the heating device consisting of wire baskets and a machine to manufacture them cheaply. The baskets were filled with kindling and about 25 pounds of coal. They were then scattered about the orchard, about 25 to the acre, suspended by wires to limbs of trees and by iron rods to limbs in budded orchards. This system accomplished what it was intended to do, but coal is heavy to handle and sometimes difficult to ignite, especially after a rain.

Later a firm in Los Angeles manufactured and sold a briquet; this was made after the style of the briquets used in Germany. It consisted of a tube composed of sawdust, oil-refinery refuse, and low-grade oil pressed into shape and used with or without a wick. A modification of the method was later made by introducing cheap sheet-iron stoves properly dampered, and in which the briquet material was made to burn without compression. The material to be

burned was shipped in sacks to the grower. This form of heat did the work of successful frost fighting, but had the disadvantage of being bulky, and the labor of handling both stoves and material was rather excessive and costly. The sheet-iron stove has undergone various modifications and there are patented devices of it made by persons in California, Colorado, and elsewhere.

THE USE OF OIL FOR HEAT.

In orchard heating the fuel to be depended upon must be easy to light, a fuel that will burn a long time and that will give out a great amount of heat; it must also be easily controlled in regard to temperature. Oil, in some form, doubtless best meets these requirements, but where oil is scarce and coal abundant the latter would be the cheaper fuel.

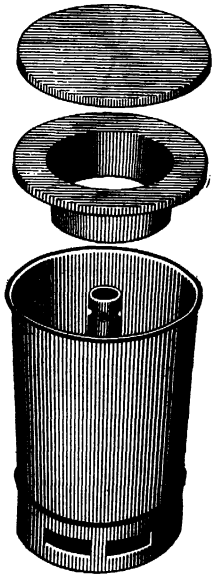

FIG. 24.—Oil heater. Capacity 7 quarts of oil.

The oil heater, so far as we know, was first manufactured by a firm in Fresno, Cal. Since then several styles of oil heaters have been manufactured and put on the market. One of these well-known and extensively used orchard oil heaters, constructed on scientific principles, has a center-draft tube that feeds oil to the flames, promotes combustion, and makes good use of the oil. The heater holds about 5 quarts of oil, will burn six or seven hours, is made of 28-gauge iron, and weighs, with cover, $1\frac{3}{4}$ pounds. It stands 11 inches high. The heaters nest nicely, fitting one into the other, for shipping purposes. The cover is made to fit like a lard-pail lid, and is raised in the center so as to shed water. This heater has successfully stood the test of several years. It is successful because based on the principle that there is no need for great heat locally, but for numerous small fires well distributed. The small fires do not necessarily change the direction of the air draft, the object being to warm up the draft as it is pressed down from above by the settling of the colder air, and thus avoid the forming of cold spots or pools. Above the danger point the upper air strata are warmer, and usually a few degrees of rise in temperature is all that is necessary for safety.

An oil heater that will hold 7 quarts of oil and burn ten hours is shown in figure 24. This heater is so arranged that the heat may be increased or diminished at will. There are larger heaters that hold 6 gallons of oil and burn thirty-five hours, but the medium size is deemed best for all practical purposes. An apple orchard equipped with oil heaters is shown in Plate XXVI.

APPLE ORCHARD EQUIPPED WITH OIL HEATERS.

An oil heater can be more easily and quickly filled and lighted than a coal heater. Crude oil has been furnished in tank lots at about 4½ cents a gallon and it makes a quick and excellent fire and an intense heat. It is a fuel that will require little or no attention after lighting, but gas oil is considered far better. By using oil one man can care for 3 to 5 acres for four hours, and this is about as long as it is customary to use a heater at any one time. One hundred oil heaters are used to the acre and they can be made to raise the temperature from 10 to 15 degrees. These heaters range in price from 15 to 25 cents apiece. The fire can be easily extinguished; the heater is perfectly adjustable and can be closed so that 4 quarts of oil will burn twenty-four hours, or the oil can burn like a bonfire and be consumed in two hours.

Heaters may not be necessary, but if needed will be needed very badly and very quickly. Anyone who has 10 acres of orchard located in the frost belt can afford to use a carload of oil. This oil may be stored in the orchard in iron tanks or in cisterns made of cement. The tanks cost about $75 each and the oil may be saved from year to year if not used. Crude oil has its objections. A disagreeable, greasy soot is produced by it which settles on trees, buildings, outbuildings, and even on the inside of buildings.

PREVENTION OF FROST INJURY POSSIBLE.

From the abundance of testimony already obtained from reliable sources in various parts of the country, it is safe to say that the prevention of frost injury to fruit crops has passed the experimental stage and has become a well-established fact that can not be controverted or lightly passed by.

For the past two years thrilling frost fights have occurred in Colorado. In 1908 two men saved large crops on the heated half of their places and lost them on the half not heated. This was a practical object lesson to fruit growers, who as soon as they saw what had been done investigated the matter thoroughly, and the growers at Canyon City appointed an orchard-heating committee, the first in existence. With $1,000 at their disposal they zealously made experiments to determine just what could be expected in the way of raising the temperature and what the cost would be. For six months these experiments were tried with every sort of fuel and the various market devices for burning it. After an extensive investigation the committee unanimously recommended oil as fuel, it being as cheap as any other and the fires more easily obtainable. It is said that in 1909 there were orchard heaters in every fruit section in Colorado, and in some sections 80 per cent of the orchards were equipped. The statement following was made by a member of the committee.

The spring of 1909 was severe, proving to be one of the worst in the history of the State, and had lack of protection been as formerly, little, if any, fruit would have been shipped from Colorado. As it is, one of the largest crops in the history of the State will be gathered, and it is estimated that $4,000,000 was saved by orchard heaters to the fruit interests of the State.

The experiments of the orchard-heating committee (which tests are a matter of record) showed that the temperature could be raised 14 degrees on a still night with 100 pots to the acre. The experiments this past spring in time of actual danger fully substantiated the claims made by the committee.

The last night of April, 1909, the thermometer in the Canyon City district fell to 17° above zero. The orchardists with oil heaters kept the temperature up to 28 or 30 degrees, or what they considered the safety point. On the preceding night there was a terrible blizzard; the wind blew a gale and there was over 8 inches of snow, which kept the oil from burning as freely as it otherwise would, but in spite of these awful conditions the temperature was raised from 21 degrees, where it remained for over five hours, up to the safety point.

As an experiment several acres were left unprotected by heaters, heating the balance of the orchard. There is a banner crop on the heated orchard, probably more than 15,000 boxes; while on the several acres not heated, on which are 100 trees 10 years old in full bearing of late winter varieties, there will not be a box of apples. One who has never realized the relief of saving the crop can not understand the feeling. In times past Colorado growers have gone to bed knowing they would be practically ruined before morning should break, and feeling absolutely helpless to do anything to protect themselves. This year the aspect is very different; the towns and surrounding country were perfect beehives of activity, and as soon as the danger signal sounded thousands of volunteers hurried to help the orchard men, and for hours the battle waged, never slacking until the great foe was vanquished.

In this orchard district of Colorado an exceptionally large crop of fruit was marketed from the orchards where the heaters were used.

The same experiment has also been tried in New Mexico, where results were equally successful. Mr. Parker Earle, of Roswell, N. Mex., reports a case in the Pecos Valley where 2,600 oil-burning heaters of 1-gallon capacity were used on a 30-acre orchard with the result that a full crop of fruit was saved and sold for $26,000, while in the rest of the valley the apple crop was almost a complete failure.

Successful frost fighting is comparatively new. It is necessary to have a force of men, industrious, careful, painstaking, and observing to the last degree. And it is no pleasant task to rush out into the still, cold night to drudge laboriously all or a part of the night to save your own orchard or that of your neighbor. Unless the work is properly done it had better not be done at all.

As stated, the worst damage may be expected in April or during the blossoming period and the time when the fruit has set. Any temperature lower than 28° F. is likely to destroy a crop. The margin, in degrees, between danger and safety is usually small, the thermometer at such times varying for a few hours at a time from 28° to 20° F. The temperature can be raised by the oil pots at least 12 to 14 degrees.

The necessity for being prepared for frost fighting can not be too strongly urged upon orchardists. Changes in the weather are sudden and often the unexpected happens. A balmy spring morning with a southerly wind and an April shower will cause the fruit buds to burst forth prematurely; then suddenly the wind changes to the north or northwest, the clouds disperse, and a clear, cloudless night follows, when a dangerous frost will probably occur and do much damage unless the orchardist is prepared to save the crop by raising the temperature above the danger point. The freezing of the blossoms is likely to occur in the early hours before sunrise, a time when the temperature usually reaches the lowest mark. To guard against such emergencies everything should be provided for weeks in advance.

Thermometers should be placed in the orchard at convenient distances apart in order to maintain a uniform system of temperature readings, and a thermometer should also be located in an accessible spot near the house, where it may be readily seen at all times. It should not, however, be placed on the house, as the heat from the building will modify the temperature several degrees.

A device for sounding an alarm of approaching danger which is said to be in use by some orchardists consists of a specially constructed thermometer connected by wire with an electric bell located in the house. When the mercury drops to near the freezing point the bell sounds the alarm in time to arouse the inmates for immediate action. One of these thermometers, or thermostats, costs about $20.

Another electric appliance that has been used in California is the orchard heater lighter. The heaters are placed at uniform distances apart in the orchard, as previously stated, about 100 heaters to the acre. By a system of electric wiring and by means of a spark plug it is possible to light every oil heater simultaneously and almost instantly.

In the areas which are visited by killing frosts this method of insuring against possible injury is a necessity, for if the apparatus is needed it is usually at some unexpected time and it is then needed very promptly. The saving of a single crop more than compensates for the expenditure for apparatus many times over.

A rapid lighter for lighting smudge pots is a recent invention, costing about $4. It consists of a can holding about five quarts, made of heavy enameled tin, the tubes, ratchet, lever, and valves being made of brass. One gallon of liquid, consisting of half kerosene and half gasoline, or all gasoline, is put into the can. The can is carried in the left hand and a torch in the right. The torch can be so arranged as to knock or pull off the cover of the previously filled oil pot; then with the index finger of the left hand the spring-acting lever on top of the gasoline can is moved over the smudge oil pot and

instantly there drops a small teaspoonful of gasoline on top of the oil. The torch is immediately applied to the dropped gasoline, which ignites and starts the gas in the smudge oil. It requires so little time at each pot that it is hardly necessary to come to a full stop. One gallon of liquid is sufficient to light 800 smudge pots.

An orchardist does not hesitate to spend $400 for apparatus and material with which to spray his orchard in order to successfully fight insect pests and fungous diseases. The necessary apparatus for successful frost fighting is neither complicated nor costly and should be kept on hand, provided the grower's orchard is in the frost belt.

The Weather Bureau publishes a series of maximum and minimum temperatures for the various sections of the United States; it also publishes the dates of probable killing frosts, for both spring and fall, for the frost-belt districts, and in addition to this its forecasters are able to send out a warning of probable frost injury about ten to sixteen hours before frost is likely to occur.

While orchard heating is comparatively new and the system needs to be perfected in some of its minor details, many thousands of dollars can be saved annually by properly protecting the orchards from frost injury by the use of artificial heat.